

LI-ION CELL DEVELOPMENT FOR LOW TEMPERATURE APPLICATIONS

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INTRODUCTION

JPL is involved in the development of rechargeable Li-ion cells for future Mars Exploration Missions. The specific objectives are to improve the Li-ion cell cycle life performance and rate capability at low temperature ($\ll -20^\circ\text{C}$) in order to enhance survivability of the Mars lander and rover batteries. Poor Li-ion rate capability at low temperature has been attributed to: (1) the electrolytes becoming viscous or freezing⁽¹⁾ and/or (2) reduced electrode capacity that results from decreased Li diffusivity. Our efforts focus on increasing the rate capability at low temperature for Li-ion cells. In order to improve the rate capability we evaluated the following: (1) cathode performance at low temperatures, (2) electrode active material particle size on low temperature performance and (3) Li diffusivity at room temperature and low temperatures. In this paper, we will discuss the results of our study.

EXPERIMENTAL

The experimental half and full cells were evaluated, at +20, -20, -30, and -40°C, for: (1) charge/discharge characteristics, (2) faradaic utilization of the active material, (3) rate capability and (4) cycle life. The electrodes were made by spraying a solution containing electrode active material, polyvinylidene fluoride binder, and/or carbon black onto a metal foil substrate. The cells were activated with mixed solvent electrolytes containing LiPF_6 salt. Surface morphology and particle size of the electrode active material powders were examined using scanning electron microscopy.

RESULTS AND DISCUSSIONS

We have evaluated a $\text{LiCo}_{0.2}\text{Ni}_{0.8}\text{O}_2$ cathode material and the possibility of using coke as an anode material for low temperature applications. Some preliminary results of our half cell ($\text{Li}/\text{LiCo}_{0.2}\text{Ni}_{0.8}\text{O}_2$; Li/coke) studies are listed below:

(1) Evaluation of cathode performance: Fig. 1 shows cathode utilizable capacity drops from 100% at +20 °C to 70%, 60%, and 46%, at -20, -30, and -40 °C, respectively. Our experimental data indicated that utilizable cathode capacity decreases rapidly below -30 °C due to the high polarization and the slow Li diffusion. Thus, we intend to improve low temperature cathode performance, by decreasing the particle size. This will decrease the Li diffusion distance and hence, increase overall rate capability.

(2) Measurement of Li diffusivity in coke: Coke may have higher Li diffusivity than graphite at low temperature and hence, it is important to determine how lithium diffusion kinetics changes with temperatures in coke-based carbon anode materials. We have conducted an experiment using the Galvanostatic Intermittent Titration Technique (GITT) to measure the Li diffusivity at various temperatures (+20, -20, -30, -40 °C). This technique consists of applying a small constant current to the cell at the equilibrium open circuit condition, and then monitoring the electrode potential change with time due to the change of surface concentration of electroactive species at the electrode and electrolyte interface. Our finding is that the room temperature Li diffusivity in the coke material studied is $1.14 \times 10^{-9} \text{ cm}^2/\text{sec}$, however, the Li diffusivity declines to 1.38×10^{-10} , 6.64×10^{-11} , and $3.04 \times 10^{-11} \text{ cm}^2/\text{sec}$ at -20, -30, and -40 °C, respectively.

(3) Effect of coke particle size : For this study, the effect of coke particle on cell performance was investigated. The as-received coke powder was sieved to obtain small particle sizes. A number of cells were fabricated and tested at room temperature (+20 °C) as well as low temperatures (-20 °C, -30 °C) to determine their low temperature performance on the as-received and sieved powders. The results show that the cell having a carbon anode containing the smaller particle size yields the better low temperature performance.

To improve the low temperature rate capability of Li-ion cells, work on the identification of suitable electrolytes for low temperature application is currently underway and will be presented in the talk.

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REFERENCES

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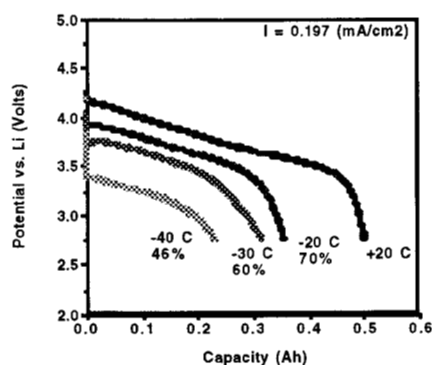


Figure 1. The performance of $\text{LiCo}_{0.2}\text{Ni}_{0.8}\text{O}_2$ cathode material charged at 20 °C and discharged at various temperatures.